T1439 - Second Beam Test of sPHENIX INTermediate Tracker (INTT)

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Motivation and Goals

sPHENIX is a proposal for a major upgrade to the PHENIX experiment at RHIC capable of measuring jets, photons, and Upsilon states to determine the temperature dependence of transport coefficients of the quark-gluon plasma. The detector needed to make these measurements require electromagnetic and hadronic calorimetry for measurements of jets, a high resolution and low mass tracking system for reconstruction of the Upsilon states, and a high speed data acquisition system.

The INTermediate Tracker (INTT) is one of the particle of sPHENIX tracking .detectors which consisted of MVTX, INTT, and TPC. The INTT detector consists of 2 barrel layers of silicon strip detectors (radius : ~ 7 and ~ 10 cm) covering an acceptance of pseudorapidity within $\pm$ 1.1, and a 2π in azimuth. The INTT prototype was first tested at the Fermi National Accelerator Laboratory (FNAL) Test Beam Facility as experiment T-1439 in March 2018. In this document, the summary of the 2nd beam test of the INTT prototype executed in May 2019 is reported.

Setup

The INTT telescope consists of four silicon strip half ladders mounted in a dark box as shown in the left panel of Fig. 1. Each half ladder consists of one flexible circuit boards called High Density Interconnect (HDI). Each HDI (approximately 350 um thick, 400 mm long, and 35 mm width) provides the slow control, power, and bias input lines as well as slow control and data output lines. The HDI was manufactured and tested by Yamashita Material co. The HDI carries two AC coupled silicon strip sensors' single side (with $26 \times 128 = 3328$ readout channels in total) located in the middle of the HDI, and 13 FPHX chips in each side of the sensors. The FPHX chip consists of 128-channel front-end ASIC, and was designed by Fermilab for the PHENIX/FVTX detector. The chip was optimized for fast trigger capability; a trigger-less data push architecture, and low power consumption (64 mW/chip). Each half ladder is mounted on one support structure (stave) made of Carbon-Fiber-Carbon composite carrying a liquid cooling tube. Each ladder is readout through an extender cable. The HDI ends was connected to a 1.2m long prototype extender cable with a 20cm conversion cable which is connected at the other end to a FVTX ROC (Readout Card) used in PHENIX/FVTX previously.This is the first time to test the full read out chain under the beam circumstance as shown in the right panel in Fig. 1.

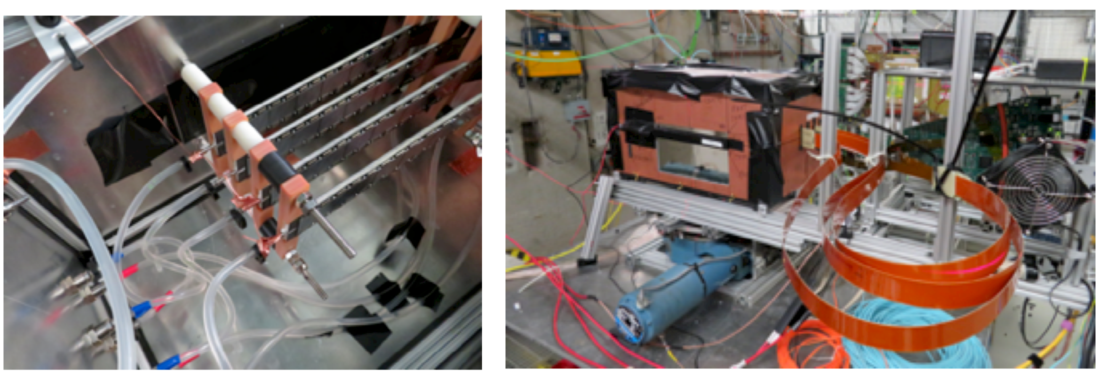

Figure 1: (left) The INTT telescope consisted of 4 silicon strip half ladders mounted in a dark box. (right) Full setup including the 1.2m long prototype bus extender cables and readout electronics card.

Results and Publications

In oder to evaluate the performance of INTT detector under various conditions, following measurements were executed.

- Timing scan to time-in

- ADC fine scan over wide range
- DAC0 threshold scan for optimization of the efficiency and S/N ratio
- Position dependent efficiency scan
- Horizontal angle dependency scan to study energy deposit in different effective thickness
- Vertical angle dependence to develop charge sharing between adjacent strips
- Rate dependent performance
- S/N and efficiency comparisons with and without the bus extender cable
- Monitoring eye diagram of the high frequency differential signal transmission with the bus extender

Shown in the left panel of Fig. 2 is the ADC spectrum of a given chip around the beam spot area. Series of measurements with the finest DAC bin setting of 3 bits ADC, but slightly shifted ADC range are concatenated into one histogram to span the wide ADC range. Clear separation between the low ADC and MIP peak around 120 channel is observed. The typical hit distributions of 3 ladders observed at 120 GeV proton beam are displayed in the right panel of Fig. 2. The y-axis and x-axis of the plot correspond to the number of hits, and silicon strip number, respectively. Each panel represents the distribution for the chip of a corresponding layout. Histograms surrounded by red dashed box is the chips in the region where being illuminated by the beam spot. The beam spot size was larger compared to the one in the 2018 beam test. To summarize, we accumulated INTT telescope data in various conditions in order to evaluate its performance in more realistic operation environment. Analysis results are to be published from NIM article within a year or so.

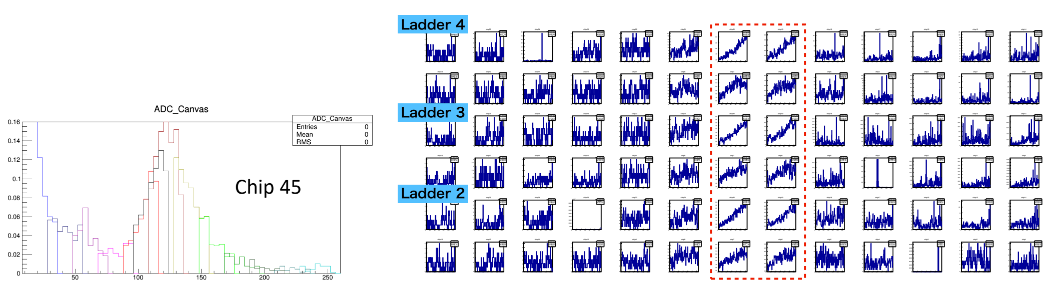

Figure 2: ADC distribution observed in one of the readout FPHX chip around the beam spot.

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